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RADIOACTIVE WASTE DISPOSAL ACTIVITIES IN THE VICINITY OF THE FARALLON ISLANDS

Interstate Electronics Corporation

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This report presents the results of a study undertaken to search for and consolidate historic information regarding the disposal of radioactive waste at locations near the Farallon islands in the waters of the Pacific ocean. Information includes an inventory of the quantities of materials dumped, approximate locations of the three known sites, a summary of general oceanographic studies in the area, and a bibliography of related documents.

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under

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ADDENDUM

Subsequent to the submittal of this report, Interstate Electronics Corporation, in conjunction with the U. S. Navy's Undersea Center, San Diego, California, performed a survey of the site designated as number 2 on page 2-3 of this report. The operation was undertaken in August, 1974, using the Cable-Controlled Underwater Recovery Vehicle, CURV III. Waste cannisters were located at a depth of 850 meters and extensive photographic and sediment data obtained. Details of this expedition, including the operational chronology and selected color plates, are presented in IEC Report 4460C1648, prepared for the U.S. Environmental Protection Agency's Ocean Disposal Program.

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Section 1

INTRODUCTION

1.1 INTRODUCTION

This limited study was undertaken to search for and to consolidate historic information regarding the disposal of radioactive waste at locations near the Farallon Islands in the waters of the Pacific Ocean. These "sites" were thought to lie approximately 48 nautical miles west of the Golden Gate Bridge, San Francisco, California. The desired end result was information relating to the following tasks:

- Inventory of radioactive wastes dumped including individual nuclides and approximate activities.
- Identification of sources of waste and organization performing the disposal operation. (This should include ships log information where obtainable but must include, as a minimum, the precise disposal coordinates and sea state.)
- Quantities and types of containers.
- Methods of packaging and methods of container identification.
- Identification of environmental radiation research and monitoring surveys conducted in area.
- General oceanographic studies which characterize the area in terms of geology, chemistry, biology, current structure, and general water circulation patterns; information which could

indicate the specific suitability of the area for ocean disposal.

- Inventory of munitions disposals in vicinity of Farallons from which to assess the relative hazards of an *in situ* study of the disposal area.

The scope of this study was relatively small, comprising approximately 80 man hours. The problem was approached by initiating a research of documents available in the IEC library, the libraries of nearby research centers, computerized document search, telephone contacts with cognizant persons, and two short field trips.

One trip was to the San Francisco area where a meeting was held with AEC personnel and a search performed in their library. A second meeting was held with representatives of the Twelfth Naval District.

A second trip was made to the San Diego area where the archives and files of the Scripps Institution of Oceanography were researched and visits made to Lockheed Ocean Laboratory and the U. S. Navy's Naval Underseas Research and Development Center.

1.2 SUMMARY

Although limited in scope, this study has determined that:

1. There is small probability that munitions exist in the area of concern.

2. The radioactive disposal "site" is actually three sites of vastly different depths and environmental habitats.

3. The exact number of containers is not known, but probably is on the order of 47,000 containers.

4. The contents of the containers is not known and may be also an undeterminable value. Estimates vary by several orders of magnitude (in curies).

5. Oceanographic data for the disposal area is not readily availabl nor of a quality necessary for a site evaluation.

6. The present probable condition of the containers is unknown.

The findings and recommendations are presented in more detail in the following sections.

Section 2

RESEARCH FINDINGS

2.1 RESEARCH RESULTS

This research program was initiated by contacting individuals associated with the radioactive waste disposal field. Name and telephone numbers of these people were screened from previous IEC contact lists. A listing of these contacts is provided in Section 7. Jointly with the initial telephone contacts, a literature search was performed which was amplified by information received during the telephone contact program. Subsequently, a field investigator visited the San Francisco area for meetings with the Atomic Energy Commission and the Twelfth Naval District. Another field investigator visited the San Diego area where contacts were established with the Marine Physical Laboratory of Scripps Institution of Oceanography, U. S. Navy's Undersea Center, COMSUBDEBEL PAC, and Lockheed Ocean Laboratories. A synopsis of findings is presented in the following paragraphs.

Disposal of radioactive wastes in the Farallon Islands area began in 1946. It was initially performed in a manner that was referred to as a "garbage disposal type of operation".[20] Contaminated material was packed in drums, taken out to convenient locations and dumped overboard. There was no administrative or technical control of these operations, as at that time, none was required by law. As the quantities increased, changes in dumping procedures were made. These changes were instituted, primarily, to preclude

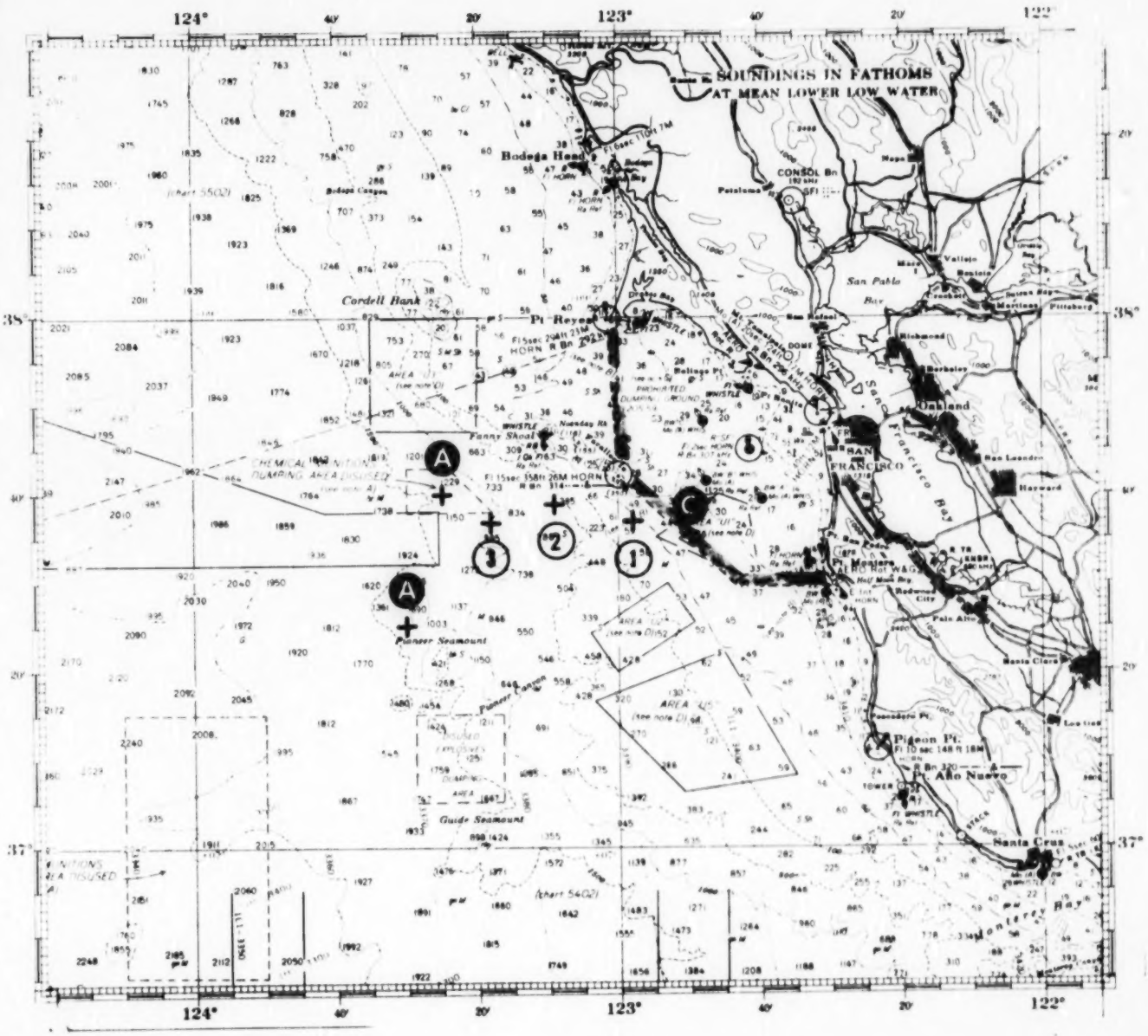
hazards in the handling of the material, rather than to provide precise operational control (such as would be necessary to permit relocation of the sites in the future). The most accurate summary of the disposal operations is contained in WASH-734 by Arnold B. Joseph[20] and a subsequent article in the National Academy of Science publication Radioactivity in the Marine Environment.[9]

The disposal of radioactive wastes at this "site" has the longest history of all Pacific coast disposal areas. The locations shown on Figure 2-1 as (1), (2), and (3) indicate the locations within the "site" that were officially used for dumping. The first site, inshore at the 50-fathom line, received three tugboat loads of material in 1946. It is thought that dumping in this area resulted from a typographical error on orders to the dumping vessel operators. Later in 1946, dumping was changed to location (3). This location was used until 1951 when location (2) was designated. Location (2) was used from 1951 to January 1954, when location (3) was redesignated as the authorized disposal site.[20]

The bulk of the material was dumped in location (3), which is in water averaging 1000 fathoms. In addition, scattered dumping, reportedly due to inclement weather, occurred closer to shore. We estimate the following distribution of containers:

Site (1)	150
Site (2)	3,600
Site (3)	44,000

Figure 2-1



Legend

A - Munitions disposal sites
C - Cannery wastes sites
1, 2, 3 - Radioactive waste disposal sites

Both LORAN and SHORAN navigation aids were available in the area during the time span in which waste disposal was carried out (1946-1966). These systems permit location within 0.5-1 nautical miles in any weather, therefore, it is possible that disposal at sites (2) and (3) took place relatively close to the designated locations. Dumping of wastes in non-designated areas as a result of bad weather occurred, but only for small quantities. Table 2-1 summarizes disposal operations.

The question as to the proper number of containers that were disposed of is still not, and may not ever be, positively determined. A possible reason for differences between AEC numbers from San Francisco and Washington may be the Naval Radiological Defense Laboratory operation that Waldichuk mentions as not included in his table on page 61.(18)

At a meeting with AEC representatives, it was confirmed that AEC records of local disposal operations had been destroyed, and not archived, during or prior to the move from Berkeley to Oakland. There is a possibility that summaries may have been forwarded to the Oakridge Laboratory, but we were unable to identify them within the scope of this study. It was also confirmed that these three sites were used by the Naval Radiological Defense Laboratory as stated by Michael Waldichuk in his paper. The Naval Radiological Defense Laboratory no longer exists at Hunter's Point Naval Shipyard. They were responsible for collecting, packaging and making arrangements for transportation and dumping. The possibility exists that some of these records may be in the San Bruno Archives, however, they would

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TABLE 2-1

	* 1946-1951	* 1952	* 1953-1954	* 1955-1956	** 1957-1958	*** 1959-1960	*** 1961-1962	*** 1963-1964	*** 1965	Totals
No. of Containers All Types	3,019	1,144	3,603	4,964	11,575	14,311	8,913	8	4	47,541
No. of 55-Gallon Drums	3,000	1,132	3,548	4,900	Individual containers were not given in more recent literature, only total numbers.					
No. of Concrete "Vaults"	19	12	55	64						
Estimated Activity at Time of Packaging (curies)***	------	------	14,061-	------	------	155.7	235.1	16.1	0.4	14,468.3

*from Joseph, Arnold B. "United States' Sea Disposal Operations - A Summary to December 1956" Atomic Energy Commission 1957, WASH-734 (20)

**Computed as difference of 1946-1956 data of Joseph, A. B. (WASH-734) and 1946-1958 data of Joseph, A.B., et al 1971 (NAS document)

***from Joseph, A.B. et al "Radioactivity in the Marine Environment, Chapter 2" National Academy of Sciences, 1971 (9)

be filed under a route slip coding scheme which would require extensive research effort to find. As mentioned above, these may show the "missing" container numbers information.

Disposal of material from the Lawrence Radiation Laboratory in Livermore, California, stopped in 1958. Material disposed of between 1963 and 1966 consists of only a few barrels from random sources. An interesting comment was made in reference to a disposal operation in mid-Pacific by ships of opportunity. Apparently there were instances of operations where small quantities were loaded on cargo ships with instructions to be dropped over the side in deep water in mid-Pacific. Records of this operation, also, no longer exist. This operation is mentioned here, because these isolated instances may account for the apparent difficulty in resolving the totals for containers of all types shown in different reports.

Radioactive waste was predominantly packaged in 55-gallon drums. Detailed descriptions of the packaging methods used are contained in WASH-734.(20) Approximately 150 concrete vaults were used for waste disposal. These vaults were 5x8x7 feet and constructed of steel reinforced concrete. Contents consisted of contaminated equipment, and used laboratory supplies. The weight of a block was approximately twenty tons (loaded). Nineteen vaults were disposed of in the period 1946-51. It is believed that all were dumped at site (2) and not dumped at the 50 fathom site, as containers of this size are too large to be handled by tugboats. These vaults were termed "glove

box packages" and were used as a standard disposal container. They were reported to contain two to ten curies of activity. However, it is reported that several contained as much as 500 curies.

Level of radiation disposed of is open to question. As an example, quoting from Waldichuk (reference (18), page 66, paragraph 5.2), "...Such concrete boxes usually contain from 2 to 10 curies of activity each. Several are known to have contained as much as 500 curies..." Arnold B. Joseph, another authority (reference (20)), states on page 2 of his report, "...The categorized numbers of drums are probably close to actuality whereas the estimated curie content could be off as much as a factor of 10..." On page 3 of Joseph's report he states, "...The amount of radioactivity contained in the drum packages ranges from 0 to 1000 millicuries; the average is estimated to be nearer 50..." The absence of any detailed manifest sheets listing the drums, their contents, the measured dose rates at the surface of the drum or other package, and their rated curie content prevents accurate assessment.

2.2 ENVIRONMENTAL STUDIES OF RADIOACTIVE WASTE DISPOSAL SITES

Although we found repeated references using words such as "keen interest in radiological processes...", "continuing liaison is maintained between the U.S. AEC and oceanographers...", and other allusions to special conferences considering problems of ocean disposal, we were unable to uncover any comprehensive surveys of Pacific Coast radioactive waste

dispcsal sites that would result in a cumulation of pertinent qualitative data including the impact of the material after disposal on the biota. Such studies that were made were primarily concerned with testing of the containers. Minor sampling programs were carried on immediately after disposal. Scientific curiosity should be aroused when one realizes that the concrete used in encasing the radioactive waste was not considered to be very consistent and was often of poor quality. The drums were freshly painted before disposal.

Waldichuk estimated a life of 10 years for the metal drum and a possible life of 30 years for the concrete filler. The estimated survival time of the concrete vault boxes is also approximately 30 years. Material at these locations is rapidly reaching this age. John Isaacs (personal communications with Waldichuk) reported collapse within the upper 200 fathoms during tests carried out by Scripps Institution of Oceanography of the same type of drums used for radioactive waste disposal. This indicates that drums disposed of at the two deep water sites probably collapsed during descent.

As with the physical and radiological parameters, little is known about the impact of the radioactive waste on benthic biota. The area is of commercial and sport fishery importance. Albacore tuna, two species of salmon and anchovies are found there. Pelagic fish in the upper areas of the sea migrate frequently, bottom fish and benthic biota frequently exhibit only small migrations, and therefore may be exposed to the radioactive material for longer periods of time.

The most comprehensive work in this area, based on actual in-situ studies, was the report TID-13665, "Survey of Radioactive Waste Disposal Sites" (reference (23)). In this study, the Pneumodynamics Corporation performed surveys in 1960 at two areas of the Farallon site number (3) (Figure 2-1). In addition, they performed a survey in the Santa Cruz Basin and at a control area off Point Arguello.

Their survey included water samples, sediment samples, biological trawls, plankton tows and fish traps. At the Farallon site, there were five bottom trawls, one mid-water trawl, and a vertical plankton tow. In addition, they took thirteen cores and eighteen water samples. Extensive benthic photography was done using an Edgerton camera. However, out of 6,500 exposures, only two pictures showed drums, which questions the accuracy of their positioning with regard to the actual points where the disposal was made.

We recommend, in future surveys of this nature, that emphasis be placed on obtaining samples of benthic biota in close proximity to the drum clusters or other waste containers. Sampling should be verified by photographic or CCTV coverage, preferably with documented indication of the actual distances involved. This would have been beyond the state-of-the-art for the period that the Pneumodynamics study was made, but is well within the capabilities of existing sampling equipment.

Section 3

METEOROLOGY AND OCEANOGRAPHY

3.1 CLIMATOLOGY

Due to the influence of the ocean and the generally westerly winds, the coastal area of San Francisco has a climate that is mild in comparison to cities at similar latitudes. Temperature variations are small, both between day and night and from month to month. Day to night temperatures vary by about 5°C and the largest month to month variation is about 2.8°C (November to December).

Westerly winds prevail in this section of the Pacific coast throughout the greater part of the year; northerly winds are most prevalent during December and January. Southerly gales occur in the winter.

During certain times of the year, especially in May and June, the northwesterly winds attain high velocity. In the winter, the most prevalent high wind is from the southeast and is followed by a southwesterly wind.

The San Francisco Bay region has comparatively few storms. Except in the winter, very few low-pressure areas move from the ocean across California; nearly all the storms that enter the United States from the west pass far northward of central California.

Wind

The prevailing flow of the San Francisco Bay area is largely determined by the position of the semipermanent high-pressure area over the eastern Pacific Ocean. Its center reaches its most northern point in July and August, and because it is so persistent, the rain-producing low-pressure areas that move through in the winter rarely affect the California coast during the summer. The strong surface heating over the interior of California, Nevada, and Arizona cause low pressure to the east, resulting in the strongest horizontal pressure differences and therefore the strongest average winds in summer. In the winter, the Pacific Anticyclone (high-pressure area) moves southward, the continent cools, pressure differences along the coast are smaller and winds are weaker, except during the periods when moving low-pressure areas (cyclones) strike the area.

Throughout most of the year, the wind direction is from the sector west to north-northwest. Only during two or three winter months is there a moderate incidence of southeast winds; these occur principally at night and in the early morning hours. During the spring, summer, and early fall, typically, the northwest winds to the west of the Pacific coastline are drawn into the interior through the Golden Gate.

Although the average wind speed is least in winter, the strongest peak speeds occur then. With the approach of migratory cyclones (low-pressure centers), the winds typically come from the southwest, and after the centers move to the east, the winds turn to northwest. These low-pressure centers and their

associated frontal systems affect the area with a frequency of about once every two weeks in winter; above average winds exist for about two days during the passage of each system.

The average hourly wind velocity at San Francisco is nearly 10 miles per hour, with highest velocity in late afternoon (4-5 p.m.), and least velocity about 6 a.m.

Precipitation

Almost 90% of the annual precipitation of the San Francisco Bay area occurs during the months of November to April. The periods of precipatation are associated with the passage from west to east of low-pressure areas and their frontal systems. Most of the precipitation occurs in the southwest flow that usually precedes the cyclones.

Although most precipitation occurs in the southwest to west flow in advance of low-pressure areas and front moving in from the west, some rain does fall in the northwest flow following the passage of the storm systems. This precipitation is usually in the form of squalls (lines of showers).

Although noted for fogs and overcast skies, San Francisco experiences about 63% of the possible sunshine over a year. The area offshore has a lower figure because fogs do not penetrate into the city as soon as they cover the offshore area.

In common with the more northerly section of the Pacific coast of the United States, the San Francisco Bay entrance experiences fog more frequently during the summer than during the other seasons. Fog is generally brought in from seaward by westerly winds about sundown, and ordinarily continues until about noon of the following day.

Table 3-1 has been assembled from various publications (34), (35), (36), and summarizes some climatological conditions of the Farallon Islands area. All parameters marked SF are from data taken in San Francisco city.

TABLE 3-1

CLIMATOLOGY

	SF AIR TEMP (°C)	AIR TEMP (°F)	PRECIP-ITATION (inches)	SF WIND SPEED (MPH)	PREV-AILING WINDS	SF WIND DIRECT-TION	FOG	SF PERCENT SUNSHINE (%)
January	9.6	51	4.90	7.2		S	7.3	50
February	10.7		3.55	7.6		W	9.7	63
March	11.1		3.36	9.1		W	3.7	67
April	12.1	52	1.64	10.3		W	5.0	66
May	13.1		0.73	11.5	19	WNW	6.5	67
June	13.5		0.16	12.9	18	WNW	9.4	75
July	13.6	54	0.02	13.4	16	WNW	14.0	68
August	13.9		0.02	12.5	14	WNW	12.4	61
September	15.0		0.32	10.3	13	WNW	9.1	68
October	14.7	55	1.00	8.0		W	12.8	68
November	12.9		2.55	6.8		W	11.4	58
December	10.1		4.51	6.7		NW	8.3	54
Annual	12.6	53	22.60	9.7		W	9.2	63

3.2 BATHYMETRY AND GEOLOGY

The area of interest is located about 180 nautical miles south of the Mendocino Ridge and 40-50 nautical miles southwest of the Golden Gate. It is bounded on the east by the continental shelf. The continental rise here is formed by the Delgada Deep Sea Fan. Seafloor gradients in the area range from 0° 21' on the abyssal plane to 5° 40' on the continental slope. Although several hills and seamounts protrude through the continental rise, they are not present in the vicinity of the area, where low local relief on the western side generally prevails.

Sediments in the area are highly variable and are derived primarily from the continental shelf. Transportation is via canyons indenting the shelf that intercept migrating longshore sediments. The continental rise is composed almost entirely of terrigenous material. This material was deposited initially in pre-Pleistocene time and continued through the Pleistocene when lowered sea level enabled sediments to reach the canyon heads more readily. Present deposition rates are much lower than during the Pleistocene. Sediments are mainly silts and clayey silts with occasional sand stringers derived from turbidity currents. Deposition rates, ranging from 0.68 cm/1000 years to 1.15 cm/1000 years have been reported, are not sufficient to result in covering of the radioactive waste containers.

3.3 OCEANOGRAPHY

Our investigation revealed no oceanographic studies of the specific site area. As reported for the CHASE site shown as A (north) on Figure 2-1,

surface temperatures range between 8.9° and 17.5°C during the year. At 2000 meters, the average for temperature is about 2.0°C, for salinity about 34.60 o/co, and for density (sigma-t) about 27.68. The surface thermal layer is mixed to about 10 meters during January through September and to 20 meters during October through December. The density layer is mixed to about 30 meters during January through March and to between 10 and 25 meters during the remainder of the year. Upwelling occurs during June through September. Data on annual temperature, salinity, and density profiles for this area are shown in Figure 3-1.

Wind velocity and wave height data from reference (33) are presented in Figure 3-2. Table 3-2 is a brief summary of environmental parameters for the area.

3.4 CURRENTS

The currents at the entrance to San Francisco Bay are variable, uncertain, and at times attain considerable velocity. Immediately outside the Bar, there is a slight current to the northward and westward, known as the Coast Eddy Current. The currents at San Francisco Lightship are described in some detail in the Tidal Current Tables. Reference (38) contains extensive information on surface currents at the old San Francisco Light Vessel shown as R"SF" on Figure 2-1, which is somewhat out of the area of interest. The currents most affecting navigation in this vicinity are the tidal currents. Across the Bar, the flood current converges toward the entrance. The ebb current spreads from the entrance over the Bar, but

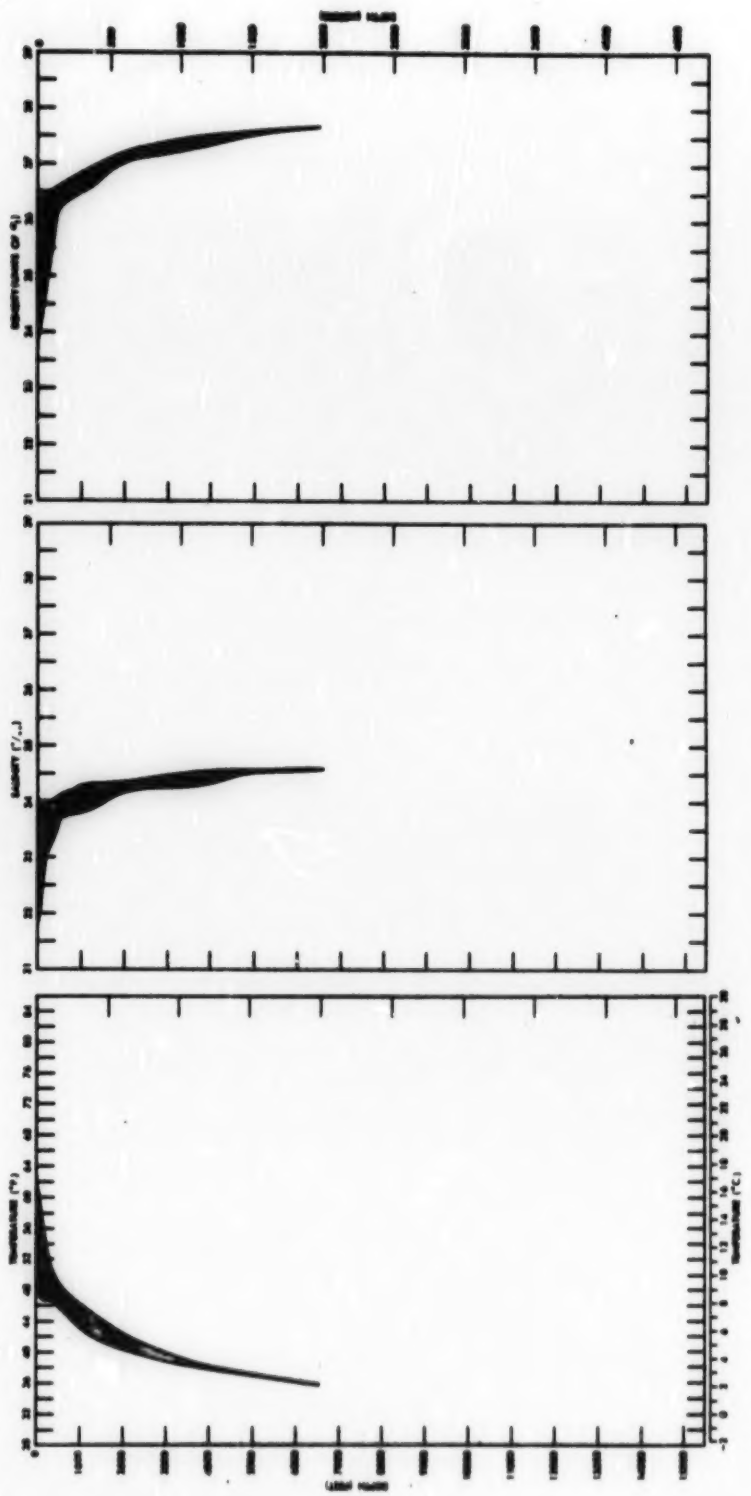

Figure 3-1

ANNUAL RANGE OF TEMPERATURE, SALINITY, AND DENSITY, AREA I

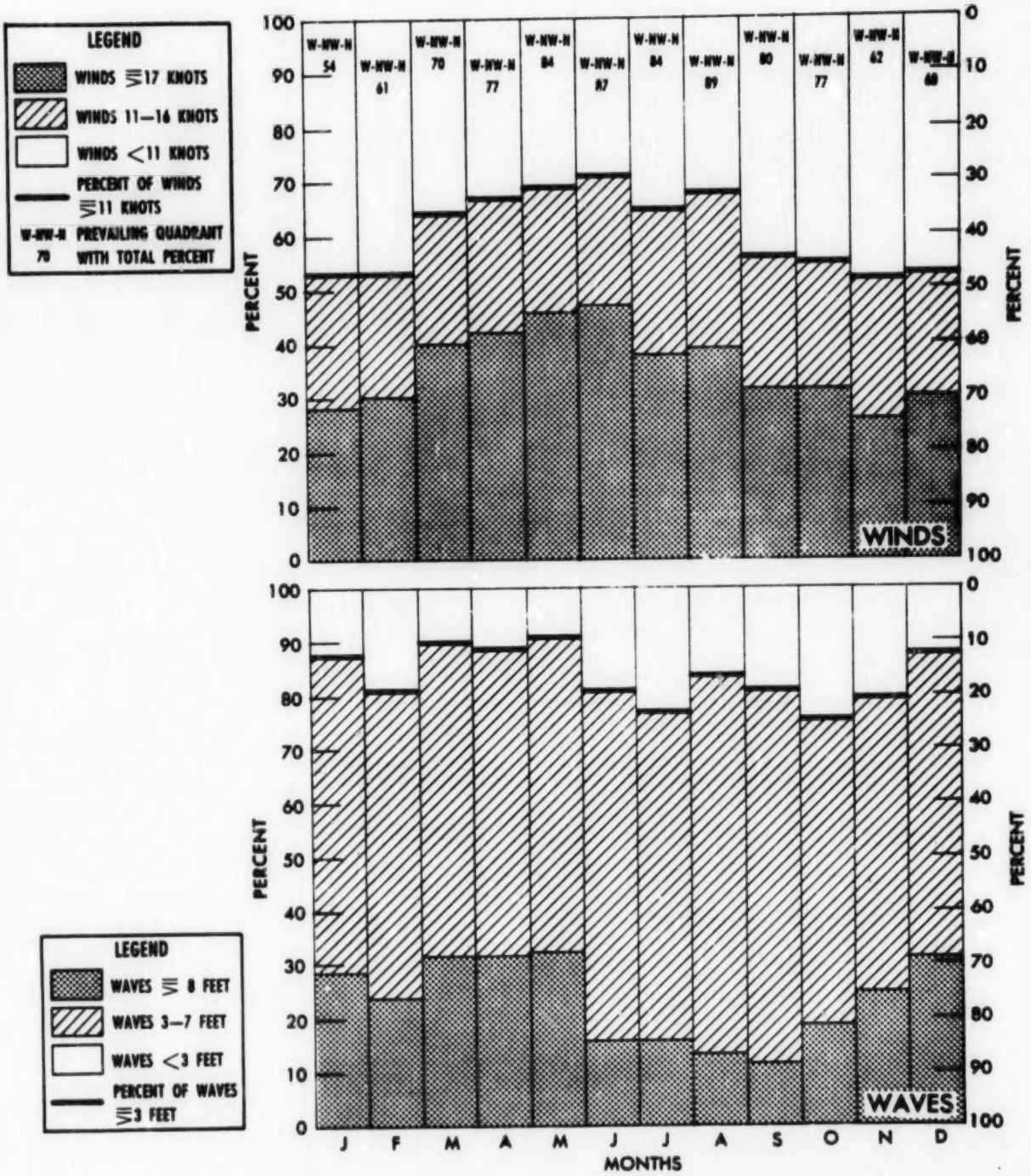

Figure 3-2

WIND VELOCITY AND WAVE HEIGHT DATA, AREA I

Table 3-2

SELECTED ENVIRONMENTAL PARAMETERS

DWD AREA POSITION	I 37°40'N 123°25'W
DWD Operation	I, 23 July 1964
DEPTH (METERS)	2000 (6570')
TEMP: SURFACE	8.9°-17.5°C
TEMP: BOTTOM	2.0°C
MEAN SALINITY SURFACE	33.30 o/oo
MEAN SALINITY BOTTOM	34.60 o/oo
MEAN CURRENTS: SURFACE	30 cm/sec (0.6 kn) S, Jan. through Oct. 25 cm/sec (0.5 kn) N, Nov. and Dec.
MEAN CURRENTS: BOTTOM	5-25 cm/sec (0.1-0.5 kn) March, E to W
WAVE HT: 8 FEET LOW	September (12%)
WAVE HT: 8 FEET HIGH	May (33%)
PREVAILING WIND DIRECTIONS	Northwest all year
SEAFLOOR GRADIENT	1:10
LOCAL RELIEF	High
SEDIMENT TYPE	Mainly terrigenous silts, silty clays
MAJOR FISHERIES	Albacore tuna, 2 salmon species with troll lines. Anchovy with purse seines; otter trawl (shelf bottom fisheries)
LORAN A	18,735
LORAN C	— — —
Radius of 95% repeatability (feet)	

Source: Environmental Condition Report for Numbered Deep Water Munitions Dump Sites (33)

the main strength is westsouthwestward. Bottom current studies by the Geological Survey show a decided drift shoreward and toward the entrance to the Bay.

Bottom current studies were made in the general area during March of 1964 in conjunction with disposal of the first CHASE ship. As reported in reference (33), currents on the bottom ranged from 5 to 25 cm/sec with direction varying from east to west.

Surface currents are predominantly southward during January through October with a mean velocity of about 30 cm/sec (0.6 kn). During November and December, the predominant direction is northward with a mean velocity of 25 cm/sec (0.5kn). A maximum surface velocity of 183 cm/sec (3.6 kn) has been measured.

Reference (37) reported on three surveys during August 1971 in the general area shown as C on Figure 2-1. During these surveys, three current meter readings were taken at a depth of 10 feet. The data from these readings averaged over the 10-minute period showed:

2.0 knots at 60^{o}
1.09 knots at 40^{o}
1.02 knots at 10^{o}

No reference was made to time of day, tide or sea conditions.

In summary, oceanographic conditions are best in September, with late August and early October being acceptable for the conduct of on site surveys of the radioactive dump sites.

Section 4

MUNITIONS DISPOSAL

The authorized munition disposal areas off of San Francisco have been used for disposal of unserviceable and obsolete munitions and explosives for many years. Prior to 1964, the U.S. Navy routinely conducted over the side disposal of such material in the charted disposal areas.

To determine the extent of this activity; types, quantities, method of packaging materials and disposal locations, our investigators contacted cognizant officials of the Twelfth Naval District. Specific contacts included the Concord Naval Weapons Station and the San Diego office of Naval Ordnance Pacific.

Historically, routine disposal was carried out under Western Sea Frontier Command (WSFC), an organization that no longer exists. Records are supposedly stored at the San Bruno National Archives. Unfortunately, the accession codes are not useable and recovery of information would require extensive hand research at the Archives. Even with such an effort, there is still the question if what records are actually there are complete. Further complications of the problem are the existing security classifications on some of the material. In order to conduct a study of these in the future, a formal request from EPA through Naval channels will be required. After a research of these records, there would remain some question as to the

actual location of the cargo because disposal operations conditions and navigation accuracies are unknown.

Comments in references indicate that the quantities of munitions were relatively small and dumped from lighter or barges. It is doubtful if any of this material would constitute a serious hazard to submersible operation. The disposal in the area of the SS John F. Sharfroth (EC-2), a potential hazard, is discussed to provide an understanding of the problems that may be encountered. This vessel was the first of the Deep Water Dumps (DWD) ships used for the CHASE ("Cut Holes and Sink Em") program. On July 23, 1964, this vessel was scuttled an estimated 44 nautical miles westsouthwest of the Golden Gate. It was loaded with 9799 short tons of obsolete explosives. It was scheduled for scuttling in 6590 feet of water at $37^{o}41'N$, $123^{o}25'W$. Unfortunately, control of this operation was poor. No escort was provided for the operation. The navigational uncertainty around the scuttling datum was reported as being "extremely large". The vessel took two hours and 45 minutes to sink, and the cargo did not detonate and under the normal sea conditions could have moved some distance before it reached the sea floor. The Navy made no subsequent effort to verify the location.(ref. 33)

While the above presents a picture of a possible hazard, the probability is slight and can be eliminated by careful survey procedures.

Section 5

RECOMMENDATIONS

As a result of this limited study of radioactive waste disposal in the San Francisco area, some areas of definite concern have been uncovered. The following recommendations should provide valuable information on the present status of the materials and containers dumped plus verify the areas of waste disposal.

Because the shallower site (50fm) may be one that could provide material (radioactive) that can be transported in the productive zone and possibly onto the beaches or San Francisco Bay itself, a program to study the status of containers at this (50fm) site should be initiated as a first priority. Additionally, this site is one of lowest relief and depth, of the three, and would be the most economical to begin operations of this type. It should be noted that it is also the smallest, in number of containers, which makes the search difficult.

The 500 fm site could be studied after the 50 fm site. It poses problems for some types of work because of the relief, which is somewhat irregular.

The 1000 fm site is closest to the munitions dump site and also in an area of great relief. Also, the greater distance from shore could be a problem

in the inaccuracies in placing the containers that are probably, at least, directly related to distance from shore.

A suggested procedure for conducting a study would be:

1. Perform an intensive search for information on the waste disposal operation and for oceanographic data.
2. Perform a sidescan sonar and magnetometer survey of the site.
3. Select candidate areas for extensive bottom sampling and visual observation by submersible.

Section 6

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